Tertiary Xenophoridae (Gastropoda) of western South America

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ABSTRACT

Three species of Xenophoridae are reported from the Tertiary of western South America: *Xenophora cardiligera* new species from the Oligocene of Peru, *Xenophora paulinae* new species from the Miocene Navidad Formation of central Chile, and *Stellaria kriegerbartholdi* new species from the Tertiary of Peninsula Arauco, south-central Chile. All of these species are first records of Xenophoridae for the respective countries. The relationship of South American *Xenophora* species with Tertiary New Zealand taxa and the difficulty in identifying a species closely related to the other South American *Stellaria* are discussed.

INTRODUCTION

Xenophoridae are a group of exclusively warm-water marine gastropods. The biology, fossil history, and taxonomy of 25 recent species has been reviewed by Ponder (1983), who recognized the single genus *Xenophora* Fischer von Waldheim, 1807, including the subgenera *Xenophora sensu stricto*, *Onustus* Swainson, 1840, and *Stellaria* Schmidt, 1832. However, most workers now recognize these at the generic rank (e.g., Kreipl and Alf, 1999), a view that is followed here. Where known, the protoconch in *Xenophora* species consists of about 3.5 low trochospiral whorls (Bandel, 1993; pl. 12, fig. 1), a type of morphology that indicates planktotrophic development, which in turn suggests long-distance dispersal.

Ponder (1983) also described Tertiary fossil species from Australia, while in an earlier work, Ben (1977) reviewed the Cenozoic Xenophoridae of New Zealand which include an Eocene to Miocene species, a Miocene species and a Pliocene to Recent species. Until now, Cenozoic Xenophoridae have never been recorded from Peru or Chile.

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GEOLOGY OF FOSSIL-BEARING LOCALITIES

Pisco Basin, Peru

The Pisco Basin of southern Peru (Figure 1) is a forearc basin (Dunbar et al., 1990) with four depositional sequences containing upper Eocene, Oligocene, lower to middle Miocene, and middle Miocene to lower Pliocene shelf and littoral deposits (DeVries, 1998). Specimens of *Xenophora* are most often found in massive, bioturbated, medium-grained sandstones of the Oligocene Otuma Formation between Paracas and Bahía de la Independencia (Figure 1), together with valves of *Cardita newcelli* Rivera, 1957. The *Xenophora*-bearing sandstones interpreted as shallow-water nearshore shelf deposits, overlie a basal transgressive sequence of medium-bedded coarse-grained sandstones with nearly monospecific molluscan assemblages of *Turritella* or *Ostrea*, and underlie a thick sequence of thin-bedded, tuffaceous, fine-grained siltstones with thin-shelled valves of *Chlamys* and fish scales of sardines and anchovies (DeVries, 1998).

Internal molds of probable *Xenophora* species are also found in a fault-bound outcrop of pebbly coarse grained sandstone overlooking the lower Río Ica valley (Figure 1). The molluscan fauna associated with the molds suggest a late Eocene age and hence assignment to the Paracas Group.

Navidad Formation, Central Chile

The Navidad Formation (Darwin, 1846) is known for a rich molluscan fauna that was last reviewed extensively by Philippi (1887). Sediment deposition as indicated by microfossils ranges from intertidal to outer shelf. Most of the specimens of *Xenophora* described here have been recovered from gray deepwater siltstone that today forms the intertidal platform at Punta Perro (Figure 2). These deposits have been dated with foraminifers by Dremel (in Herm, 1969, p. 71) as Lower Miocene (Burdigalian). However, Tsuchi et al. (1990) and Ibaraki

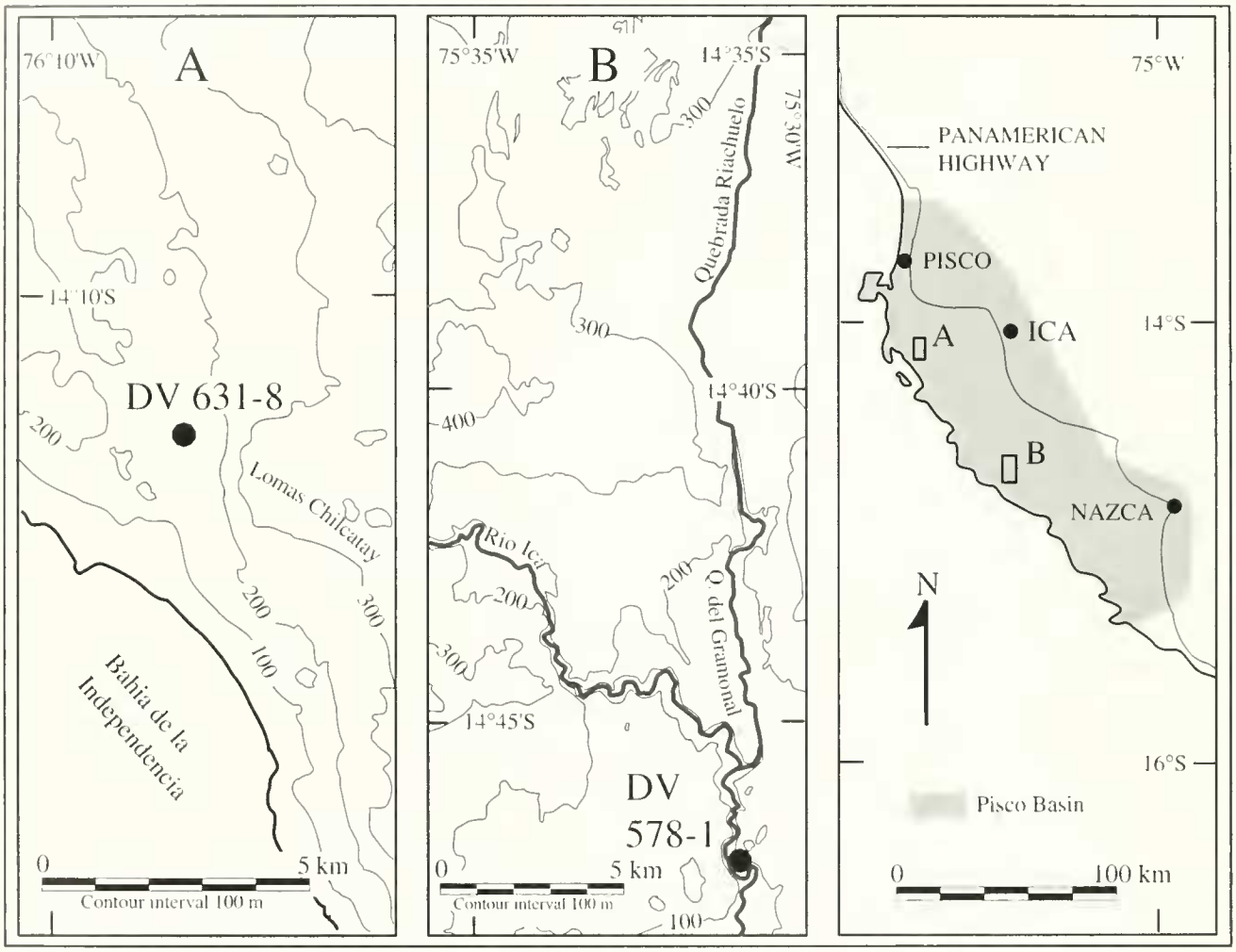


Figure 1. Fossil localities for *Xenophora carditigera* in the Pisco Basin of Peru.

(1992) have pointed out that an Upper Miocene age (Tortonian) is more likely.

Additional specimens have been collected north of the Río Rapel and from Matanzas, both also in the area of Navidad (Figure 2). The sediments of these localities are believed to be contemporaneous with those of Punta Perro.

Millongue Formation, Península Arauco, south-central Chile

The Millongue Formation has been defined from cores drilled on Península Arauco. It consists of gray siltstones dated as Tortonian (see García, 1968). All similar siltstones of this [illegible] have been considered to belong in this formation. However, analysis of the molluscan fauna suggests a Miocene age at least for part of these sediments (S. Nielsen, unpublished data).

The *Stellaria* specimen described herein was found in a concretionary nodule from a coastal cliff with exposures of gray siltstones to the east of Punta Millongue (Figure 2). These concretionary nodules are washed free by the tide and usually yield specimens of the crab *Cancer araucanus* Philippi, 1887. Because this locality has not been dated until now, the age of the *Stellaria* remains uncertain.

MATERIALS AND METHODS

Specimens described or mentioned in this study are deposited in the collections of the following museums: Departamento de Paleontología de Vertebrados, Museo de Historia Natural de la Universidad de San Marcos, Lima, Perú (MUSM INV); Departamento de Paleontología de Invertebrados, Museo Nacional de Historia Natural, Santiago de Chile (SGO.PI); and Senckenberg Museum, Frankfurt, Germany (SMF). Photographs were taken using a Leicaflex SL2 camera. Images were scanned from Ilford FP4 125 black and white 35 mm negatives using an Acer ScanWit 2720S film scanner and processed with Photoshop 6.0.

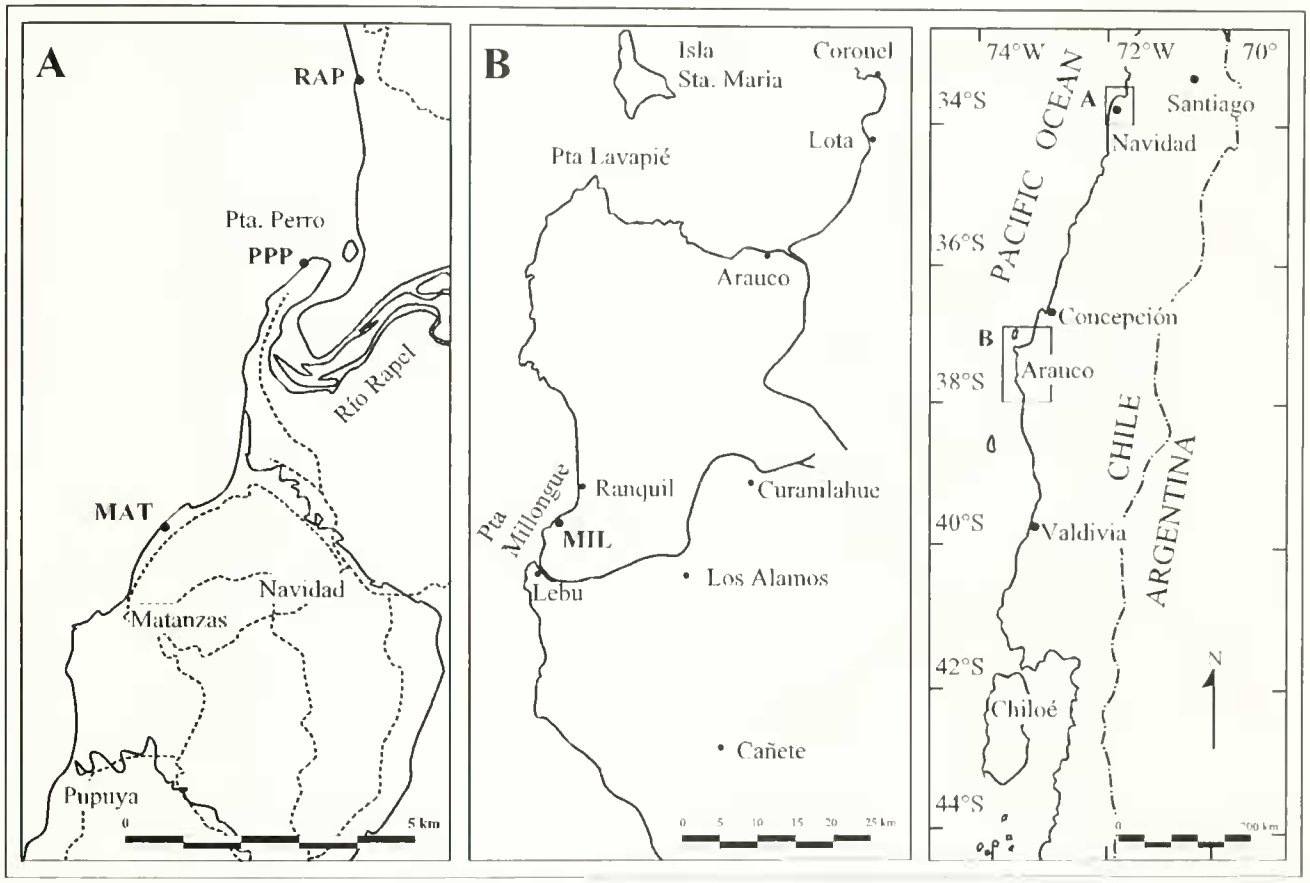


Figure 2. Fossil localities for *Xenophora paulinae* (Navidad area) and *Stellaria kriegerbartholdi* (Peninsula Arauco) in Central Chile.

SYSTEMATIC PALEONTOLOGY

Family Xenophoridae Philippi, 1853
Genus *Xenophora* Fischer von Waldheim, 1807

Type Species: *Xenophora laevigata* Fischer von Waldheim, 1807 (= *Trochus conchyliophorus* Born, 1780).

Xenophora carditigera new species
(Figures 3–11)

Diagnosis: Moderate size, moderately tall spire; base without spiral sculpture; dorsal surface with weakly opisthocline to spiral irregular lirae.

Description: Diameter up to 36 mm. Spire angle 70–90°; whorls and spire flat-sided to very slightly convex. Protoconch poorly preserved. Base flat to slightly concave; neither spiral nor subspiral sculpture (lines, threads, rugae) evident; colabral growth lines and ridges present. No umbilicus in adults; none evident in juveniles; thick columella. Dorsal surface with weak prosocline growth lines and coarse, wavy lirae that are weakly opisthocline to irregularly spiral. No prosocline nor opisthocline axial cords. Cemented objects evenly spaced, about seven per whorl, increasing in size on later whorls; less than 50% of shell covered. Aperture unknown.

Type Material: Holotype SMF 323039 (figures 3–5), height 17 mm, diameter 36 mm; 5 paratypes: SMF 323040, height 16 mm, diameter 30 mm, SMF 323041 (figures 6–8), height 13.5 mm, diameter 22.5 mm, MUSM INV 1 (figures 9–11), height 21 mm, diameter 32.5 mm, MUSM INV 2, height 15 mm, diameter 26.5 mm, MUSM INV 3, height 13 mm, diameter 21.5 mm.

Type Locality: DV 631 S, northwest of Loma Cuesta Chilcatay, about 1 km north of Comotrana-Carhuas road, about 5 km east Playa Carhuas, in ridge-forming sandstone bed, 120.5 m in measured section, 14°11′06″ S, 76°08′17″ W (Punta Grande 1:100,000 quadrangle).

Etymology: Named after *Cardita*, the bivalve most often cemented to this species, and *gera*, the Latin root signifying 'to bear or carry.'

Occurrence: Otuma Formation, Oligocene, between Paracas and Bahía de la Independencia, Peru. Possibly from the uppermost Eocene.

Discussion: Specimens of *Xenophora carditigera* new species differ in several respects from those of *X. con-*

Figures 3–12. Tertiary *Xenophora*. **3–11.** *Xenophora carditigera* new species. **3–5.** Holotype, SMF 323039, height 17 mm, diameter 36 mm. **6–8.** Paratype SMF 323041, height 13.5 mm, diameter 22.5 mm. **9–11.** Paratype MUSM INV 1, height 21 mm, diameter 32.5 mm. **12.** *Xenophora paulinae* new species. Paratype SGO.PI.5991, diameter 154 mm.

chyliophora (Born, 1780), a species with a fossil record that may extend back to the Eocene and which is presently found off the coast of both eastern and western North and Central America (Ponder, 1983). The latter species is characterized by rugose cords on the dorsal surface; wavy lirae that are distinctly opisthocline; base with weak spiral sculpture; an umbilicus in juvenile specimens; and a thin columella and umbilical callous in adults. Specimens of *X. carditigera*, in contrast, have neither rugose spiral cords, strongly opisthocline lirae, nor spiral sculpture on the base, and have a thick rather than thin columella.

Xenophora carditigera most closely resembles *X. flemingi* Beu, 1977, an early to middle Miocene species from New Zealand that may be part of a lineage that includes *X. prognata* (Finlay, 1926) (late Eocene to middle Miocene) and *X. neozelanica* Suter, 1908 (early Pliocene to Recent). Specimens of *X. flemingi* are also moderately tall and straight-sided, lack an umbilicus, have weakly developed to obsolete spiral sculpture on the base, and are only partially covered by cemented debris that increases in size towards the aperture. The principal difference between *X. carditigera* and *X. flemingi* is that dorsal lirae on the latter are distinctly opisthocline.

Xenophora paulinae new species
(Figures 12–16)

Diagnosis: Shell large, umbilicus closed, whorl outline concave. Subsutural ramp reaching halfway onto previous whorl. Dorsal surface between cemented objects with coarse wavy lirae and prosocline axial growth lines.

Description: Shell large (holotype diameter 132 mm, height 62 mm), with depressed spire (angle about 105°), peripheral flange unknown. Protoconch unknown. No umbilicus in adults (no juveniles known), whorl outline concave due to subsutural ramp reaching about halfway up onto previous whorl. Dorsal surface between cemented objects with coarse wavy lirae as well as prosocline axial growth lines. Base weakly concave, sculptured with low, narrow, irregular, collabral growth lirae. Attached camouflaging objects seem to include either high-spired gastropods or concave-side-up bivalves (up to 50 mm wide). Basal apertural lip regularly and shallowly curved. Aperture unknown.

Type Material: Holotype SMF 323042 (figures 13–14), height 62 mm, diameter 132 mm, Punta Perro; paratypes SGO.PI 5991 (figure 12), diameter 154 mm, Punta Perro, SGO.PI 5992 (figures 15–16), spire fragment, height 16 mm, Matanzas.

Type Locality: Intertidal platform at Punta Perro, central Chile.

Etymology: Named after Paulina S. Vásquez Illanes, friend and colleague, who found part of the type material.

Occurrence: Navidad Formation, Tortonian, Navidad area, central Chile.

Discussion: *Xenophora paulinae* new species differs from most other species by its large size. The only similarly large species is the Eocene to Miocene New Zealand *Xenophora prognata* (Finlay, 1926) (see Beu, 1977) from which it differs in having concave rather than convex whorls formed by a subsutural ramp reaching about halfway up onto previous whorl.

Previously, Tavera (1979) stated that his *Trochita gigantea* (also from the Navidad Area, might prove to be a *Xenophora*. However, Tavera (1979) provided no diagnosis to separate his species from other taxa, and he did not figure the specimen. Consequently the name is considered unavailable under ICZN Article 13.1.1.

Genus *Stellaria* Schmidt, 1832
Type species: *Trochus solaris* Linné, 1764.

Stellaria kriegerbartholdi new species
(Figures 17–20)

Diagnosis: Spire short, with narrow peripheral flange divided into prominent, blunt digitations. No umbilicus. Base lightly convex, with distinct collabral growth lines.

Description: Short spire, periphery divided into about 10 prominent blunt digitations. No umbilicus. Whorl outline and sculpture unknown, because original shell is dissolved except for periphery and digitations, but outline appears to be weakly convex. Base slightly convex, with distinct collabral growth lines.

Holotype: SGO.PI 5993 (figures 17–20), height 24 mm, diameter with attachments 60 mm, spire angle 95°.

Type Locality: Northeast of Playa Millongue, Peninsula Arauco, south-central Chile.

Etymology: Named after Rolf Kriegerbarthold, who did the difficult preparation of this specimen.

Occurrence: Northeast of Punta Millongue, Peninsula Arauco, south-central Chile.

Discussion: *Stellaria kriegerbartholdi* differs from all other species of this genus in having a closed umbilicus. The type species, *S. solaris*, has tubular spines, a feature that cannot be observed in *S. kriegerbartholdi*. *S. kriegerbartholdi* most resembles the Oligocene to Pliocene *S. testigera* (Bronn, 1831) (with its two Recent subspecies, in having a strongly digitate peripheral rim. *S. testigera* lived in the Mediterranean and spread to Atlantic Africa and the Gulf of Aden. As suggested by Ponder (1983), *X. testigera* could have evolved from the Eocene *S. conica* (Dall, 1892) from Mississippi, which also might be regarded as ancestral to *S. kriegerbartholdi*. *S. conica* has the umbilicus almost obscured by the parietal callus (McNeil and Dockery, 1984). The completely closed umbilicus would also justify inclusion of this species in *Xenophora*, suggesting that this species or species line lost its camouflaging habit and evolved from a different ancestor than *Stellaria* s.s. However, this view is not followed here.

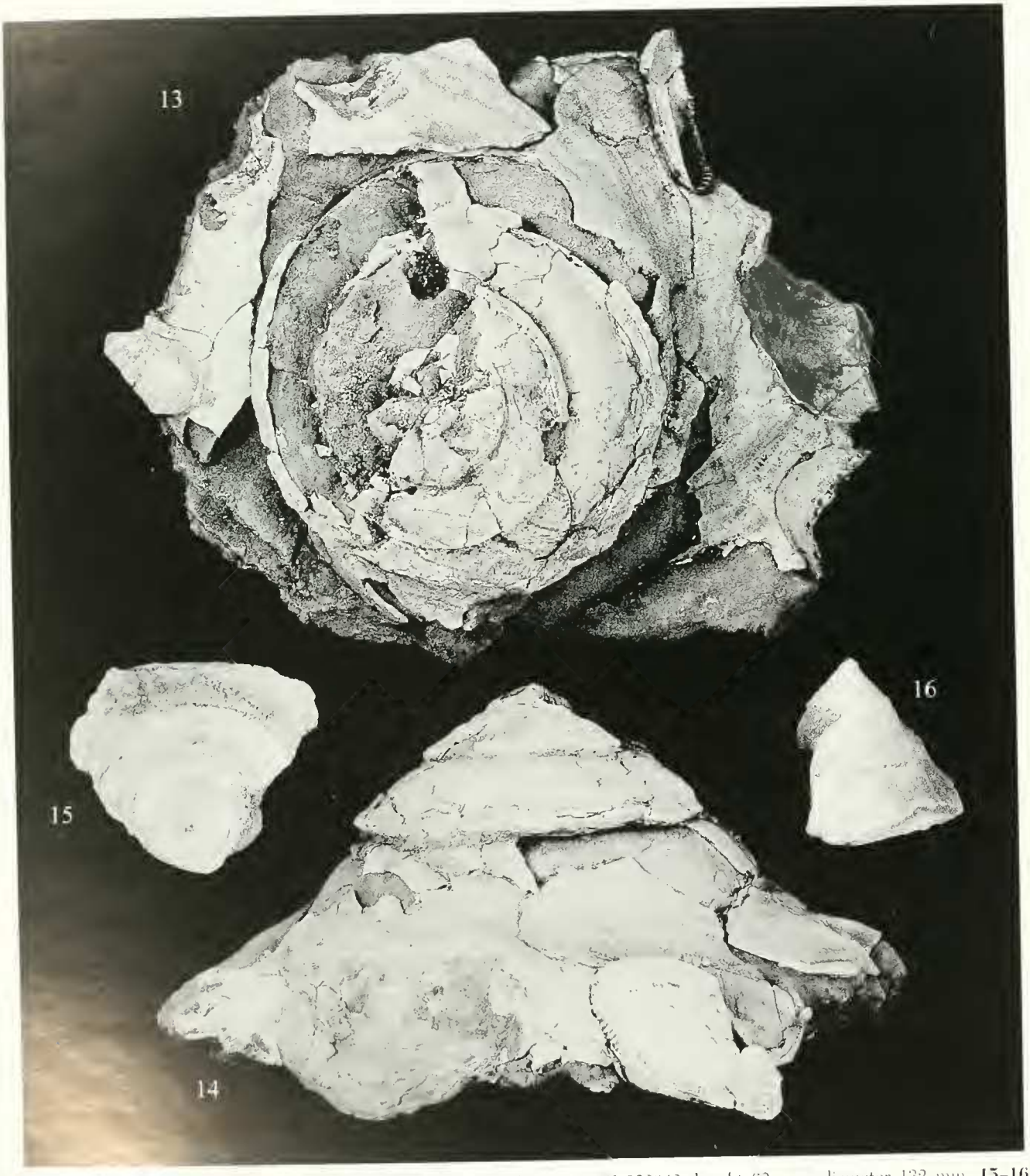
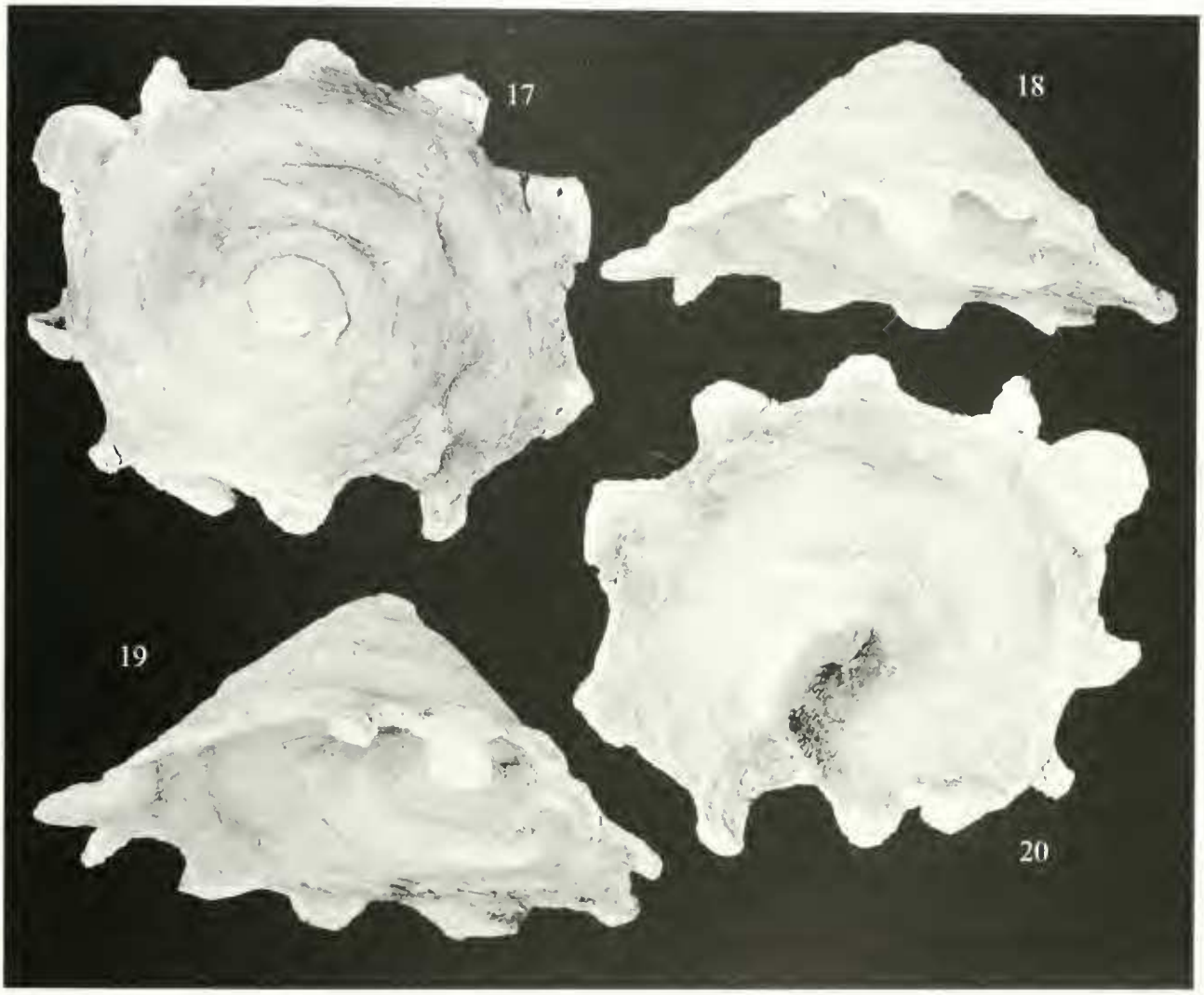


Figure [illegible] *Xenophora paulinae* new species. **13–14.** Holotype, SMF 323042, height 62 mm, diameter 132 mm. **15–16.** Paratype [illegible] 92, spire fragment, height 16 mm.

Remarks: [illegible] for *Stellaria* given by Ponder (1983) has to [illegible] to include species with a closed umbilicus. [illegible] *S. kriegerbartholdi* Ponder (1983) noted that the placement of *S. testigera* "is not completely satisfactory", a comment which is even more appropriate for *S. kriegerbartholdi*. It does not seem justified to erect a new genus for this species because a closed umbilicus is also present in *Xenophora* and, therefore, seems to be an old invention of the family. Characters separating *Stellaria* from *Xenophora* are reduced



Figures 17–20. *Stellaria kriegerbartholdi* new species. Holotype, SGO PI 5993, height 24 mm, diameter with attachments 60 mm.

to the presence of spines or digitations, an expanded peripheral flange and a nearly smooth dorsal surface.

CONCLUSIONS

The Cenozoic Xenophoridae of Chile and Peru close a considerable biogeographic gap in the history of the family. Oligocene records of *Xenophora* are few but the genus was already established in Australia (Ponder 1983) and New Zealand (Ben 1977) in the Eocene. In the Miocene the genus was widespread in the Indo-Pacific Region with three species also present in the Caribbean Sea. Today only the type species, *X. conchyliophora* remains in the Americas (Ponder 1983).

Our two species of *Xenophora* seem closely allied with New Zealand species. Similarities between faunas from New Zealand and Argentina have recently been indicated by Ben et al. (1997). Our records of *Xenophora* show that there are even more connections with Pacific South America, a fact which is, of course, not surprising. More trans-Pacific affinities can be expected from further studies of Pacific South American faunas.

Stellaria conica from Eocene beds of Mississippi may be an ancestor of *S. kriegerbartholdi* but has an open umbilicus like modern species. Ponder (1983) discussed *S. testigera* as a possible early offshoot while *Stellaria* was still close to *Xenophora*, which may also be true for *S. kriegerbartholdi*. However, characters of the known *Stellaria* species suggest that the fossil record of this genus is very fragmentary.

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